

X. *The Fossil Flora of the Culm Measures of North-west Devon, and the Palaeobotanical Evidence with Regard to the Age of the Beds.*

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[PLATES 19 AND 20.]

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I. *Introduction.*

THE deposits of Upper Palæozoic age in the south-west of England differ remarkably in their general characters from those developed on the north side of the Bristol Channel. This conclusion applies not only to the Devonian rocks, but also to the succeeding Carboniferous series. In South Wales and Monmouth, the Devonian beds are of the Old Red Sandstone type, whereas, the Devonian succession of North Devon exhibits a marked, though not an entire change, in both petrological characters and palæontological facies; a change which becomes even more marked in the series of limestones, volcanic, and detrital deposits developed in the southern portion of that county.

The South Wales coalfield, the largest and most important productive measures in

this country, consists of a sequence of coal-bearing strata, resting upon beds of Lower Carboniferous age, for the most part similar in character to those occurring in our other English coalfields. In Devonshire, and in portions of the neighbouring counties of Somerset and Cornwall, a Carboniferous basin of considerable size is developed, occupying more than 1,200 square miles. In many important respects these rocks again differ somewhat markedly from their equivalents in South Wales. They form a succession of deposits of a somewhat abnormal type; being composed of sediments of extremely varied nature and origin, both detrital and organic. They are especially characterised by a general absence of carbonaceous material of any economic importance. These Carboniferous rocks are spoken of as the Culm Measures, a name first applied to them by SEDGWICK and MURCHISON* in 1837. These authors† in their classic memoir, published in 1840, gave the first accurate description of the physical structure of the beds, and proved conclusively their Carboniferous age. It may be pointed out, however, that DE LA BECHE,‡ in 1834, was the first to indicate the Upper Carboniferous age of that portion of the Culm Measures which forms the subject of this memoir; his conclusion being based on plant remains identified by Professor LINDLEY. DE LA BECHE§ also added considerably to our knowledge of the Culm Measures in his 'Report on the Geology of Cornwall and Devon,' published in 1839. Since then, JOHN PHILLIPS,|| HOLL,¶ T. M. HALL,** and others,†† and, in more recent times, Messrs. HINDE and FOX,‡‡ and Mr. USSHER,§§ have all contributed important information on this subject.

SEDGWICK and MURCHISON showed that the Culm Measures of Devon and the adjacent counties, occupy a true basin or synclinal fold between the Devonian succession in North and South Devon; the lower beds of the Culm Measures occupying the northern and southern margins. They instituted a two-fold subdivision of these beds, the Lower, and the Upper Culm Measures, and, although, in more recent times Mr. USSHER||| has urged the acceptance of a three-fold division, SEDGWICK and MURCHISON's classification is adopted here, for reasons which will be explained at a later stage in this work.

NOTE.—The numbers in parentheses after the authors' names denote the year of publication of the memoir, to which reference will be found in the bibliography at the end of this paper.

* SEDGWICK and MURCHISON (37), p. 557.

† SEDGWICK and MURCHISON (40).

‡ DE LA BECHE (34).

§ DE LA BECHE (39).

|| PHILLIPS (41).

¶ HOLL (68).

** HALL (75) and (78).

†† See bibliography at the end of this paper.

‡‡ HINDE and FOX (95).

§§ USSHER (92) and (01).

||| USSHER, *ibid.*

At the present time our knowledge of the Lower Culm Measures is on an altogether different footing to that of the Upper Division. This is almost entirely due to an important paper published in 1895, by Messrs. HINDE and FOX, in which the petrological characters and fauna of these beds were fully and admirably described. These authors showed that this division is of Lower Carboniferous age, and that it consists of Radiolarian cherts, overlying inconstant and impersistent limestones* in some areas, and dark shales; the latter apparently forming the basement beds. Above the Radiolarian rocks, commonly known as the Coddon Hill Cherts, lies the great series of sandstones and shales constituting the Upper Culm Measures, and forming by far the thickest portion of the Culm Measures in Devon. Owing, however, to the highly folded, contorted, and faulted nature of the strata, as the result of earth movements, it has not so far been possible to arrive at even an approximate estimate of the thickness of either of these divisions. It is, however, beyond dispute† that the Upper Culm Measures are of far greater vertical extent than the lower series.

These upper beds were not dealt with by Messrs. HINDE and FOX‡ in the paper referred to, although they expressed the opinion that “the question of their relative age can be determined only by their plant-remains.”

The present paper is an attempt to add to our knowledge of the fossil flora of the Upper Culm Measures, more especially with a view to determining the horizons in the Upper Carboniferous which are represented in Devon. No attempt has been made here to unravel the extremely complicated geological structure of the district. Attention has, so far, been entirely devoted to the task of the collection of plant remains from the one horizon in the Upper Culm Measures in which carbonaceous deposits of appreciable thickness occur—a task rendered extremely difficult owing to the crushing and severe folding which the area has undergone in common with the rest of the Culm Measures.

The occurrence of an impure smutty coal, known locally as “culm” or “anthracite,” is confined to a small area, for the most part in the neighbourhood of Bideford in North-west Devon. Such deposits are altogether absent in the Lower Culm Measures, and, with the exception of occasional carbonaceous partings in the shales and sandstones of the Upper Culm Measures of other districts, are not found elsewhere in either North or South Devon. This coal has in the past been largely worked in the Bideford district, the material being used in the manufacture of black paint, and also to some extent as a rough fuel. It is at present only mined at East-the-Water, Bideford.

The coal or “culm” is not only of local occurrence, but is practically limited to one horizon in the Upper Culm Measures. It forms a number of discontinuous and

* Mr. USSHER is inclined to regard the limestones as superior to the Coddon Hill beds. See USSHER (92), p. 121.

† See Mr. USSHER's recent map (01), Plate 16; also HINDE and FOX (95), p. 662.

‡ HINDE and FOX (95), p. 663.

inconstant bands of no great thickness, which range from the western coast at Greenacliff* in almost a straight line through Bideford for a distance of some 12 miles to the east, near Chittlehampton. The position of these bands is shown on the only Survey Map of North Devon so far published, that of DE LA BECHE, surveyed upwards of 60 years ago.† All the bands do not appear to lie on exactly the same horizon, several of them being parallel to one another, although they are all very closely associated. For the purposes which we are considering here, they may, however, be regarded as constituting one horizon, and are therefore of special value, for it has so far proved exceedingly difficult to recognise definite lithological horizons in the Upper Culm Measures, or to trace any particular beds from place to place, on account of the greatly disturbed nature of the rocks.

There is no reason to doubt that the horizon of the coal-bearing strata, near Bideford, lies nearer the base than the summit of the Upper Culm Measures, although, for reasons already explained, it is almost impossible to arrive at even an approximate idea of the thickness of the series until the district has been mapped in detail.

From a palæobotanical standpoint the Culm Measures offer a most unpromising field. Although, as will be seen, a considerable number of species have already been described from the horizon of the culm or anthracite, it is nowadays a matter of the greatest difficulty to obtain specimens sufficiently well preserved to admit of satisfactory determination. All the plants described here have been obtained from the beds closely associated with the "culm," and are, therefore, practically from one horizon in the Upper Culm Measures.

I would wish to express here my obligations and thanks to several geologists who have given me useful information, or obtained for me the loan of specimens. I am especially indebted to Mr. INKERMANN ROGERS, of Bideford, who has generously placed his splendid collection of Culm Measure plants, gathered as the result of much patience and perseverance, at my disposal for examination and description. I am under great obligations to him, not only for the assistance he has rendered me during my visits to the Bideford district, but for the time which he has devoted, often at personal inconvenience, to the collection of specimens with a view to helping forward this work. To my friend, Mr. KIDSTON, F.R.S., I am indebted for assistance in difficulties of identification and for valuable advice. Mr. VIDAL, of Fremington, has rendered me great services by his local knowledge, and by guidance in the field. I am similarly indebted to Mr. HAMLING, F.G.S., of Barnstaple, especially for facilities for studying the specimens in the Hall Collection of Culm Measure plants at Barnstaple. I would also wish to express my thanks to the Director of the

* Also known as Greencliff.

† Mr. ROGERS, of Bideford, has kindly re-examined for me the direction of the several bands of culm or anthracite, and his conclusions agree in general with those of DE LA BECHE. For a description of the culm beds, see DE LA BECHE (39), p. 124 and p. 513, &c., HALL (75) and (78), and USSHER (92), p. 150.

Geological Survey for permission to examine the Culm Measure fossils in the Jermyn Street Museum, and to the Keeper of the Geological Department of the British Museum (Nat. Hist.) for access to similar specimens under his care. My sincere thanks are also due to Professor McKENNY HUGHES, F.R.S., on whose staff I have the honour to serve, for constant sympathy and encouragement in this and other palæobotanical work.

A.—THE FOSSIL FLORA OF THE UPPER CULM MEASURES.

II. *Previous Records of Fossil Plants.*

In almost every description of the rocks of the Upper Culm Measures in the neighbourhood of Bideford, mention is made of the common occurrence of plant remains. The name “floriferous slates” was, on this account, proposed for these beds by WILLIAMS in 1839. As a rule, however, such fossils are extremely badly preserved, and quite incapable of specific determination. A number of specimens have, however, been previously identified from North Devon, and these, so far as I am aware, were in all cases derived from the beds associated with the “anthracite or culm,” or from the neighbouring grits and shales.

The earliest record of the discovery of specimens, sufficiently well preserved to admit of identification, is that of the collection formed by DE LA BECHE,* from the anthracite near Bideford. These plants were identified by LINDLEY, and his results were communicated to the Geological Society at the end of the year 1834.

LINDLEY'S Determinations.		Modern Names.†
<i>Pecopteris lonchitica</i>	=	<i>Alethopteris lonchitica</i> (SCHL.).
<i>Sphenopteris latifolia</i>	=	<i>Mariopteris latifolia</i> (BRONG.).
<i>Calamites cannaeformis</i> ‡	=	? <i>C. suckowi</i> , BRONG.
<i>Asterophyllites</i> resembling <i>A. longifolia</i>	=	<i>Calamocladus longifolius</i> (SCHL.).
<i>A. sp.</i> , which may be <i>A. galioides</i>	=	<i>A. galioides</i> (L. and H.).
<i>Cyperites bicarinata</i> .§		
<i>Lepidophyllum intermedium</i> .		

Fragments, apparently of “Palm leaves”|| were also recorded, but the most abundant plant was stated to be too imperfect for determination.

In 1840, SEDGWICK and MURCHISON¶ added a further list of species from the

* DE LA BECHE (34), p. 106, footnote.

† Where no emendation is given, the original name still holds good.

‡ See KIDSTON (91), p. 364.

§ See KIDSTON (91), p. 359.

|| Probably crushed or distorted Calamitean pith-casts.

¶ SEDGWICK and MURCHISON (40), p. 681 ; also (37), p. 562.

shales overlying the culm bands about 2 miles to the east of Bideford.* These specimens were also determined by LINDLEY.

LINDLEY'S Determinations.		Modern Names.
<i>Asterophyllites foliosa</i> , L. and H.	=	<i>Annularia radiata</i> , BRONG.
<i>Calamites undulatus</i> , BRONG.		
<i>C. sp.</i> , resembling <i>C. arenaceus</i> , BRONG.	=	<i>C. sp.</i>
<i>Cyperites bicarinata</i> , L. and H.†		
<i>Neuropteris gigantea</i> , STERNB.		
<i>N. cordata</i> , BRONG.	=	<i>N. scheuchzeri</i> , HOFFM.
<i>Pecopteris lonchitica</i> , BRONG.	=	<i>Alethopteris lonchitica</i> (SCHL.).
<i>P. muricata</i> , BRONG.		<i>Mariopteris muricata</i> (BRONG.).
<i>Poacites coriina</i> , L. and H.	=	<i>Calamites sp.</i>

Pecopteris lonchitica is stated to be "perhaps the most abundant of the Bideford plants."

DE LA BECHE‡ in his 'Report on the Geology of Cornwall, Devon, &c.' mentions a number of species from the "range of carbonaceous rocks from Bideford Bay to Hawkrudge Wood," which include several not previously recorded by him, or by SEDGWICK and MURCHISON. LINDLEY again determined these plants.

LINDLEY'S Determinations.		Modern Names.
<i>Pecopteris Serlii</i> , BRONG.	=	<i>Alethopteris serli</i> (BRONG.).
<i>P. lonchitica</i> , BRONG.	=	<i>Alethopteris lonchitica</i> (SCHL.).
<i>Neuropteris Loshii</i> , BRONG.	=	<i>N. heterophylla</i> , BRONG.
<i>N. heterophylla</i> , BRONG.		
<i>Sphenopteris acuta</i> , BRONG.		

"Leaves of monocotyledonous plants § of three or four species hitherto undescribed," and "probably also *Calamites nodosus*,|| and one which somewhat resembles *C. Steinhauri*,"|| were also found, as well as "several species, unknown to Dr. LINDLEY, of the genera *Pecopteris*, *Asterophyllites*, *Sphenophyllum*, *Lepidodendron*, and *Poacites*.¶

MURCHISON** in his 'Silurian System' gives a list of eight species all of which were previously mentioned in his conjoint paper with SEDGWICK. In PHILLIP'S†† 'Palæozoic fossils of Cornwall, Devon, &c.' no record or figure is given of any plant remains from the Culm Measures.

* Possibly from Webbery Wood, see p. 299.

† See KIDSTON (91), p. 359.

‡ DE LA BECHE (39), p. 126.

§ Probably imperfect Calamitean casts.

|| *Calamites sp.* This is not a good species.

¶ Probably imperfect Calamitean casts.

** MURCHISON (39), p. 85.

†† PHILLIPS (41).

It may be also noticed that, in 1842, AUSTEN* recorded *Pecopteris lonchitica*, *Neuropteris heterophylla*, *Sphenopteris latifolia* or *acutifolia*, *Cyclopteris* sp. and *Calamites* from the Culm Measures of South-east Devon.

More than thirty years later, the late TOWNSHEND HALL,† a local geologist, gave a list of twenty-six Culm Measure species, which included all the determinations which had been published previously.

		Modern Names.
<i>Asterophyllites foliosa</i> .	=	<i>Annularia radiata</i> , BRONG.
<i>A. galioides</i>	=	<i>Annularia galioides</i> (L. and H.).
<i>A. longifolia</i>	=	<i>Calamocladus longifolius</i> (SCHL.).
<i>Bowmanites</i> .		
<i>Calamites arenaceus</i> ?	=	<i>Calamites</i> sp.
<i>C. cannaeformis</i>	=	<i>Calamites</i> sp.‡
<i>C. nodosus</i> ?	=	<i>Calamites ramosus</i> , ART. ?
<i>C. Steinhaurii</i> ?	=	<i>Calamites</i> sp.‡
<i>C. undulatus</i> .		
<i>Cyperites bicarinata</i> .		
<i>Lepidodendron</i> .		
<i>Lepidophyllum intermedium</i> .		
<i>Neuropteris cordata</i>	=	<i>N. scheuchzeri</i> . HOFFM.
<i>N. gigantea</i> .		
<i>N. heterophylla</i> .		
<i>N. Loshii</i>	=	<i>N. heterophylla</i> , BRONG.
<i>Pecopteris lonchitica</i>	=	<i>Alethopteris lonchitica</i> (SCHL.).
<i>P. muricata</i>	=	<i>Mariopteris muricata</i> (BRONG.).
<i>P. Serlii</i>	=	<i>Alethopteris serli</i> (BRONG.).
<i>Poacites cocoina</i>	=	<i>Calamites</i> sp.
<i>Sigillaria</i> .		
<i>Sphenopteris acuta</i> .		
<i>S. latifolia</i>	=	<i>Mariopteris latifolia</i> (BRONG.).
<i>Sphenophyllum</i> sp. ?		
<i>Sternbergia</i>	=	<i>Cordailes</i> sp.
<i>Stigmaria ficoides</i> .		

In 1878 the same author § gave a very similar list, and, so far as I am aware, this is the latest record of plants which were undoubtedly obtained from the Culm Measures. HULL,|| in the fourth edition of 'The Coal-fields of Great Britain,' says that twenty-three species, including one marine plant, have been obtained from the "Culm," but gives no further details.

* AUSTEN (42), p. 461.

† HALL (75), p. 375.

‡ These species have no definite specific characters. They are probably all Stylocalamitean casts, and some of them may possibly be identical with *C. suckowi*, BRONG.

§ HALL (78), p. 66.

|| HULL (81), p. 64.

In 1884, Mr. KIDSTON* determined a number of plant remains, which were sent to him as probably derived from the Culm Measures, but without record of localities or horizons. Among the nine plants which he identified were *Asterocalamites scrobiculatus* (SCHL.), *Calamites Roemeri*, GÖPP., *Lepidodendron Rhodeanum*?, and a new species of *Sphenopteris*. Chiefly on the occurrence of these species he regarded this flora as having a "Calciforous Sandstone facies." It has been already pointed out by Messrs. HINDE and FOX† that there is no doubt that, while some of the specimens determined by Mr. KIDSTON may have been obtained from the Culm Measures, the above-mentioned species were derived from the Upper Devonian rocks (Marwood or *Cucullea* beds) at Sloy Quarry, near Barnstaple. Some of these plants are in the Athenæum Museum at Barnstaple. These records must, therefore, be excluded from any consideration of the Culm Measure flora.

III. *Localities from which the Specimens, described in this Paper, were obtained.*

The best preserved specimens have been found to occur, as a rule, in the black, highly carbonaceous shales closely associated with the smutty coal or culm. Thin partings of such shales also occur here and there in the sandstones and grits at some distance from the culm bands, and fossil plants have occasionally been found in them.

At East-the-Water, Bideford, the culm is still worked in a "Paint Mine" belonging to Mr. POLLARD, but no well-preserved specimens have been obtained from this locality. In Broadstone Quarry, near to the present culm workings, an adit through one of the culm-bands has been made, for the purpose of draining the quarry, and from the *débris* removed, or from the carbonaceous shales *in situ*, the specimens of *Lepidodendron fusiforme* and *Neuropteris schlehani*, figured here, were collected, in association with *Alethopteris serli*, *Calamites*, *Sphenophyllum*, *Renaultia*, *Sigillaria*, *Stigmaria*, and *Cordaite*.

In the neighbourhood of the present "Paint Mine," traces of former culm pits occur at Moor Park, and it was no doubt from these workings that the fine and interesting specimen of *Alethopteris lonchitica*, figured on Plate 20, fig. 15, was derived, which is now preserved in the Jermyn Street Museum.‡

Further to the east, at a spot some 500 yards to the north-west of Warmington Farm, a culm-band crops out, and Mr. ROGERS has here obtained specimens of *Alethopteris*, *Mariopteris*, and *Stigmaria*.

There is a specimen in the Athenæum Museum, Barnstaple, of *Lepidodendron obovatum*, which was derived from the western limit of the culm, where it is exposed

* KIDSTON (84¹), p. 534, and (84²), p. 59.

† HINDE and FOX (95), p. 653.

‡ Registered number, 8423. Formerly in the collection of Lieut.-Colonel HARDING,

in the sea-cliff at Greenacliff. I have also collected *Sigillaria* from the same locality.

To the east of Bideford, a culm-band occurs near the village of *Alverdiscott*. Several specimens, collected by the late TOWNSHEND HALL, and now in the Athenæum, Barnstaple, are labelled with this locality. They include *Megalopteris* (?) *sp.*, and *Alethopteris lonchitica*, which are here figured, and also *Pinnularia*, the root of a Calamite.

Somewhat nearer to Bideford, numerous old culm workings may be found in Webbery Wood, and possibly this may have been the locality from which the species described by SEDGWICK and MURCHISON were obtained. I have not, however, been able to obtain further specimens from this culm band, as the former workings are now almost entirely obliterated.

The most important workings for culm, which have existed in past times, were probably those at Hiscott in the parish of Tawstock, at some distance to the east of Bideford, and to the south of Barnstaple. The culm-bands here were worked in the eighteenth century.* Mr. ROGERS has, on several occasions, carefully examined the *débris* around the old culm pits at Summer Hiscott, and has been successful in obtaining several well-preserved specimens from the dark carbonaceous shales. The examples figured here of *Alethopteris serli*, *Lepidophloios acerosus*, *Sigillaria tessellata*, and *Lepidodendron aculeatum* were collected from these beds. *Calamostachys longifolia*, *Calamocladus charæformis*, *Alethopteris lonchitica*, *Neuropteris obliqua*, *Sphenophyllum*, and *Mariopteris* also occur here.

The sandstones and shales on or near the horizon of the culm-bands have occasionally been found to yield well-preserved plant remains, though as a rule they are entirely barren, or the fossils are so badly preserved that specific identification is impossible. These rocks belong to the petrological facies termed by Mr. USSHER† the *Morchard type*, which he describes as follows: "Thickly and thinly bedded, greenish-grey and reddish, much jointed sandstones, associated with ovoidally splitting shales."

The sandstones have been long quarried near the village of Abbotsham, some 2 miles to the west of Bideford, at a locality known as Pit or ROGERMAN'S quarry. Several different workings have been made here at various times, and in some of them, partings of carbonaceous shale have been found which have yielded plant remains, such as *Annularia radiata*, *Sphenophyllum sp.*, *Calamites sp.*, and *Sigillaria sp.* Mr. ROGERS has been particularly fortunate in obtaining the well-preserved specimen of *Sigillaria scutellata*, figured on Plate 19, fig. 4, from the sandstones of the present quarry. The state of preservation is here almost unique as compared with other impressions from the grits. *Trigonocarpus parkinsoni* and *Stigmaria* were also found at Pit quarry.

* HALL (75), p. 369.

† USSHER (01), p. 362; see also (92), pp. 115 and 146.

The cliff above the railway station at Bideford is largely composed of thick shales, which have yielded numerous *Calamites* of various species, some of which are figured here. In a small sandstone quarry, belonging to the Rev. E. ROBERTS, of Bideford, at East-the-Water, and near the "paint mine" already mentioned, ovoidally splitting, highly ferruginous shales are seen. These have been carefully examined, and from them the figured specimens of *Urnatopteris tenella*, *Mariopteris muricata* were obtained, as well as numerous *Calamites*, and such types of Calamitean foliage as *Annularia radiata*, *A. galioides*, and *Calamocladus equisetiformis*.

There are very few specimens of fossil plants from the Culm Measures to be found in any museum. The British Museum (Natural History), possesses two collections, but few of the specimens are well preserved. One, presented by the Rev. W. BILTON in 1837, was chiefly obtained from Bideford and Northam. Many of the specimens* are, however, too poorly preserved to admit of specific determination. The other† formed part of the late TOWNSHEND HALL'S collection, purchased in 1886, nearly all of which were derived from Pit quarry, Abbotsham. The remainder of HALL'S collection is in the museum of the Athenæum, Barnstaple. These specimens are described here, with the exception of a Calamite-like cast from Burrington, which I have been unable to determine.

The Jermyn Street Museum has the fine specimen of *Alethopteris lonchitica* already mentioned, and also a Calamitean-like cast (No. 8425), stated to be from Crediton. There are a few badly preserved *Calamites* from the Culm Measures in the museum of the Geological Society. I have not, however, been able to trace either SEDGWICK and MURCHISON'S or DE LA BECHE'S collections.

Most of the specimens described here were obtained during the past year specially for this memoir. The majority of them are from the fine collection of Mr. ROGERS, of Bideford, which it is hoped will eventually find a place in the British Museum. The specimens which I have collected during my visits to the Bideford district are now incorporated with the collections in the Sedgwick (Woodwardian) Museum, Cambridge (Carboniferous Plant collection, Nos. 1130–1156).

* Registered numbers in the Geological Department, 145–219.

† Registered numbers in the Geological Department, V 3561–74.

IV. *Description of Specimens.*

EQUISETALES.

Calamites. SUCKOW, 1784. ('Act. Acad. Elect. Theod.-Palat.,' vol. 5, p. 355).

1. *Calamites (Calamitina) undulatus*, STERNBERG. Plate 19, figs. 1 and 3.

1828. *Calamites undulatus*, BRONGNIART, 'Hist. végét. foss.,' p. 127, Plate 17, figs. 1-4.

1886. *Calamites undulatus*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 338, Plate 54, figs. 1 and 4.

Several specimens of *Calamites undulatus* have been obtained from the cliff above Bideford railway station. The two specimens from Mr. ROGERS's collection, figured here, show the flexuous character of the longitudinal ridges on the internodes. That on Plate 19, fig. 1, is a slightly enlarged photograph of a node, showing the characteristic termination of the ridges. The pith cast shown on fig. 3 of the same plate is reduced to half natural size. The flexuous ridges are here very clear.

2. *Calamites (Eucalamites) ramosus*, ARTIS. Plate 19, fig. 2.

1884. *Calamites (Eucalamites) ramosus*, WEISS, 'Steinkohl.-Calamarien,' Part 2, p. 98, Plate 2, fig. 3; Plate 5, figs. 1 and 2; Plate 6, figs. 1-7; Plate 7, figs. 1 and 2; Plate 8, figs. 1, 2, 4; Plate 9, figs. 1 and 2; Plate 10, fig. 1; Plate 20, figs. 1 and 2.

1887. *Calamites ramosus*, STUR., 'Die Calamarien Carbon.-Flora Schatz. Schicht.,' p. 96, Plate 12, figs. 1-4; Plate 12*b*, figs. 1-4 and 6; Plate 13, figs. 1-9; Plate 14, figs. 3-5, text-figs. 1 (p. 4), 31 (p. 104), 32 (p. 105).

Calamites ramosus is fairly abundant in the Culm Measures, and specimens have been obtained from the shales above the railway station, and in Mr. ROBERTS's quarry, Bideford, as well as from the present "paint mine." The specimen figured on Plate 19, fig. 2, is a fragment showing part of an internode, and a large branch scar at the node. In this species two branch scars of large size occur at every node. *Annularia radiata* is the foliage of this species.

3. *Calamites (Stylocalamites) suckowi*, BRONGNIART.

1828. *Calamites Suckowii*, BRONGNIART, 'Hist. végét. foss.,' p. 124, Plate 15, figs. 1-6; Plate 16, figs. 2-4.

1876-84. *Calamites Suckowi*, WEISS, 'Steinkohl.-Calamarien,' Part 1, p. 123, Plate 19, fig. 1; Part 2, p. 129, Plate 2, fig. 1; Plate 3, figs. 2, 3; Plate 4, fig. 1; Plate 27, fig. 3.

Calamites Suckowi is apparently not uncommon in the Culm Measures, specimens having been obtained from Broadstone, and ROBERTS's quarries at East-the-Water, Bideford. This species is one of the commonest in the Coal Measures.

4. *Calamites (Calamitina) varians*. STERNBERG.

1828. *Calamites dubius*, BRONGNIART, 'Hist. végét. foss.,' p. 130, Plate 18, figs. 1-3.

1884. *Calamites varians*, WEISS, 'Steinkohl.-Calamarien,' Part 2, p. 6, Plate 25, fig. 2; Plate 27, fig. 2; Plate 28, figs. 1-2 and 4.

The only specimens of *Calamites varians* from the Culm Measures which I have seen are two in the British Museum (Natural History), (V. 3563 and V. 3569), one of which was obtained by TOWNSHEND HALL from Pit quarry, Abbotsham.

Calamites sp. (External surface of the stem.)

MR. ROGERS has in his collection (No. 54) a small fragment of a Calamite obtained from Broadstone quarry, Bideford, which exhibits the external surface of the bark and some branch scars at the node. The specimen is too fragmentary to determine specifically. It is, however, interesting from the fact that such specimens are of rare occurrence in the British Coal Measures.

Annularia. STERNBERG, 1821. 'Flora der Vorwelt,' Heft 2, p. 32.

1. *Annularia radiata*. BRONGNIART.

1886. *Annularia radiata*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 394, Plate 59, fig. 8; Plate 61, figs. 1 and 2.

Annularia radiata has been collected by myself at ROBERTS's quarry, Bideford, and from Summer Hiscott by Mr. ROGERS. There is also a specimen from Abbotsham in the Athenæum Museum, Barnstaple. This type of Calamitean foliage is now known to belong to *Calamites ramosus*.

2. *Annularia galioides*. (LINDLEY and HUTTON.)

1886. *Annularia microphylla*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 392, Plate 60, figs. 3 and 4.

1893. *Annularia galioides*, KIDSTON, 'Trans. Roy. Soc.,' Edinb., vol. 37, p. 317, Plate 2, figs. 4, 4A.

I have obtained a few specimens of *Annularia galioides* from ROBERTS's quarry, Bideford, but this species has not, I believe, been found elsewhere in the Culm Measures.

Calamocladus, SCHIMPER, 1869. ('*Traité Paléont. végét.*,' vol. 1, p. 323.)

1. *Calamocladus equisetiformis* (SCHLOTHEIM).

1836. *Hippurites longifolia*, LINDLEY and HUTTON, '*Foss. Flora*,' vol. 3, Plates 190 and 191.

1886. *Asterophyllites equisetiformis*, ZEILLER, '*Flore foss. bass. houill. Valenciennes*,' p. 368, Plate 58, figs. 1-7.

A single specimen of *Calamocladus equisetiformis* has been obtained from ROBERTS'S quarry, Bideford.

2. *Calamocladus charæformis*. (STERNBERG.)

1825. *Bechera charæformis*, STERNBERG, '*Flora der Vorwelt*,' Heft 4, p. xxx, Plate 55, fig. 3.

1887. *Asterophyllites Roehli*, STUR, '*Die Calamarien Carbon-Flora Schatz. Schicht*,' p. 209, Plate 14, figs. 13*a*, 13*b*, 13*c*; Plate 15*b*, fig. 3.

Several specimens of *Calamocladus charæformis* have been obtained by Mr. ROGERS from Summer Hiscott. Mr. KIDSTON, to whom I have submitted them, agrees with this determination. *Calamocladus charæformis* is now known to be identical with SAUVEUR'S *Annularia microphylla*.

Calamostachys, SCHIMPER, 1869. ('*Traité Paléont. végét.*,' vol. 1, p. 328.)

Calamostachys longifolia, WEISS.

1876. *Calamostachys longifolia*, WEISS, '*Steinkohl.-Calamarien*,' Part 1, p. 50, Plate 10, fig. 1.

A single specimen of *Calamostachys longifolia*, obtained from Summer Hiscott, has been determined by Mr. KIDSTON, who remarks that there seems to be some confusion with regard to this cone.

Pinnularia, LINDLEY and HUTTON, 1834. ('*Fossil Flora*,' vol. 2, p. 81.)

Pinnularia sp.

Specimens of the roots of a Calamite have been obtained from ROBERTS'S quarry, Bideford, and others from Alverdiscott are in the Barnstaple Athenæum. In these specimens, there seem to be several rows of rootlets springing from the main root, or possibly the rootlets are arranged spirally; the preservation not being sufficiently good to determine the exact arrangement. Similar fossils have been figured by ARTIS in his '*Antediluvian Phytology*,' Plate 5, and by WEISS in the first part of his '*Steinkohlen Calamarien*,' Plate 30, fig. 1*A*. In other roots, included in the genus *Pinnularia*, the rootlets are arranged in two rows,

SPHENOPHYLLALES.

Sphenophyllum, BRONGNIART, 1822. ('Sur Class. végét. foss.,' p. 34.)

Sphenophyllum cuneifolium (STERNBERG).

1886. *Sphenophyllum cuneifolium*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 413, Plate 62, fig. 1; Plate 63, figs. 1-10.

1893. *Sphenophyllum cuneifolium*, ZEILLER, 'Mém. Soc. Géol. France Paléont.,' vol. 4, Mém. No. 11, p. 12, Plate 1, figs. 1-4; Plate 2, figs. 1-3; Plate 3, figs. 1 and 2.

Sphenophyllum cuneifolium is the only species which has been met with in the Culm Measures. It is fairly abundant, numerous examples having been obtained from Hiscott, from Broadstone quarry, at Bideford, and other localities.

CYCADOFILICES.

Neuropteris, BRONGNIART, 1822. ('Sur Class. végét. foss.,' p. 33.)

1. *Neuropteris obliqua* (BRONGNIART).

1832. *Pecopteris obliqua*, BRONGNIART, 'Hist. végét. foss.,' p. 320, Plate 96, figs. 1-4.

1886. *Neuropteris obliqua*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 284, Plate 48, figs. 1, 2, 4-7.

Neuropteris obliqua has been obtained from Summer Hiscott, and possibly also from ROBERTS'S quarry, Bideford.

2. *Neuropteris schlehani*, STUR. Plate 20, figs. 10 and 13.

1877. *Neuropteris Schlehani*, STUR, 'Culm Flora,' pt. 2, p. 183, Plates 11 (28), figs. 7 and 8.

1886. *Neuropteris Schlehani*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 280, Plate 46, fig. 3; Plate 47, figs. 1 and 2.

Several specimens of *Neuropteris schlehani* have been obtained by Mr. ROGERS from the culm shale at Broadstone quarry, Bideford. Two of these are figured on Plate 20, figs. 10 and 13. Both these photographs are considerably enlarged (more than three times) to show the characteristic nervation. So far as I am aware, this constitutes the first British record of STUR'S species, though Mr. KIDSTON, who has kindly identified the specimens figured here, has previously obtained specimens from the Middle Coal Measures. This frond is fairly abundant in some of the Continental coal-basins.

Alethopteris, STERNBERG, 1825. ('Flora der Vorwelt,' Heft. 4, p. xxi.)

1. *Alethopteris serli* (BRONGNIART). Plate 20, fig. 14.

1886. *Alethopteris Serli*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 234, Plate 36, figs. 1 and 2; Plate 37, figs. 1 and 2.

Alethopteris serli has been obtained by Mr. ROGERS both from Summer Hiscott, and from Broadstone quarry, Bideford. It appears, however, to be fairly rare in the Culm Measures on this horizon; at any rate it is very much less abundant than *A. lonchitica*. The enlarged photograph ($\times 3\frac{1}{3}$) on Plate 20, fig. 14, shows the characteristic habit and nervation of the pinnules; cf. *A. lonchitica*, figs. 11 and 15. *A. serli* is most abundant in the Upper Coal Measures, but is known to occur occasionally in the Middle Coal Measures of several British coalfields.

2. *Alethopteris lonchitica* (SCHLOTHEIM). Plate 20, figs. 11 and 15.

1828. *Pecopteris lonchitica*, BRONGNIART, 'Hist. végét. foss.,' p. 275, Plate 84, figs. 1-7.

1901. *Alethopteris lonchitica*, KIDSTON, 'Proc. Yorks. Geol. and Polytech. Soc.,' vol. 14, pp. 195, 219, Plate 32, figs. 2 and 3.

Alethopteris lonchitica is one of the most abundant of fern-like fronds in the Culm Measures, and has been found to occur in all the localities in which the culm-shales have been examined. The specimen figured on Plate 20, fig. 11, from Alverdiscott, shows the usual form of the pinna. Fig. 15 represents an apical portion of another pinna, in which the pinnules are not decurrent, but constricted basally, and apparently attached to the axes by very small portions of the somewhat cordate base. This variety is not rare in the Coal Measures, and is apparently very common in the Culm Measures. This specimen was obtained many years ago from Moor Park, near Bideford, and is now in the Jermyn Street Museum.

FILICALES?

Mariopteris, ZEILLER, 1879. ('Bull. Soc. Géol.,' France. Sér. 3, vol. 7, p. 92.)

Mariopteris muricata (SCHLOTHEIM). Plate 20, fig. 17.

1885. *Diplothemema muricatum*, STUR, 'Die Farne Carb.-Flora Schatz. Schicht.,' p. 393, Plate 21, figs. 1-5; Plate 22, figs. 1-5; Plate 23, figs. 1-6.

1901. *Mariopteris muricata*, KIDSTON, 'Proc. York. Geol. and Polytech. Soc.,' vol. 14, pp. 195 and 219, Plate 32, figs. 1, 1A.

Mariopteris muricata is a fairly abundant fern-like fossil in the Culm Measures in all the localities from which plants have been collected. The specimen

figured on Plate 20, fig. 17, was obtained from the ovoidally splitting shales at ROBERTS'S quarry, East-the-Water, Bideford, and is now in the Sedgwick Museum, Cambridge.

Urnatopteris, KIDSTON, 1884. ('Quart. Jour. Geol. Soc.,' vol. 40, p. 594.)

Urnatopteris tenella (BRONGNIART). Plate 19, fig. 6.

1828. *Sphenopteris tenella*, BRONGNIART, 'Hist. végét. foss.,' p. 186, Plate 49, fig. 1.

1882. *Eusphenopteris tenella*, KIDSTON, 'Ann. and Mag. Nat. Hist.,' Ser. 5, vol. 10, p. 7, Plate 1, figs. 1-6.

A solitary specimen of *Urnatopteris tenella* has been obtained from the shales exposed in Mr. ROBERTS'S quarry, East-the-Water, Bideford, and is now in Mr. ROGERS'S collection. A photograph of an enlarged drawing of this delicate frond is reproduced on Plate 19, fig. 6.

Renaultia, ZEILLER, 1883. ('Ann. Sci. Nat.,' Sér. 6, Bot., vol. 16, p. 185.)

1. *Renaultia footneri* (MARRAT).

1872. *Sphenopteris Footneri*, MARRAT, 'Proc. Liverpool Geol. Soc.,' p. 101, Plate 8, figs. 2, 3.

1890. *Sphenopteris Footneri*, KIDSTON, 'Trans. Roy. Soc.,' Edinb., vol. 35, p. 406, Plate 2, figs. 3, 3A, 3B.

Several specimens of *Renaultia footneri* have been obtained by Mr. ROGERS from Broadstone quarry, Bideford. Mr. KIDSTON, who has kindly identified this species for me, thinks that *R. footneri* may possibly be identical with *Sphenopteris gracilis* of BRONGNIART.* As, however, there would still seem to be some doubt on this question, it may be as well to maintain MARRAT'S species for the present.

2. *Renaultia schatzlarensis* (STUR.) ?

1885. *Calymmotheca schatzlarensis*, STUR, 'Die Farne Carb.-Flora Schatzl. Schicht.,' p. 265, Plate 38, figs. 1 and 2.

1888. *Crossotheca fimbriata*, KIDSTON, 'Ann. and Mag. Nat. Hist.,' Ser. 6, vol. 2, p. 23, Plate 1, figs. 1-8.

Mr. KIDSTON has somewhat doubtfully identified a specimen, obtained by Mr. ROGERS from Broadstone quarry, Bideford, as *Renaultia schatzlarensis*. It would be interesting if further examples of this plant could be obtained from the Culm Measures.

* KIDSTON (90), 4th Rep., p. 104.

Megalopteris, DAWSON, 1871. ('Foss. Plant. Dev. and Upper Sil. Canada,'
Part 1, p. 51.)

Megalopteris sp.? Plate 20, fig. 16.

The specimen figured on Plate 20, fig. 16, which is in the museum of the Athenæum, Barnstaple, is labelled as having been derived from Alverdiscott, and the shale on which it occurs corresponds closely with undoubted Culm Measure shales from that locality. The specimen is unfortunately only a small fragment of what must once have been a frond of some size. Its most striking character is the great thickness of the mid-rib. The secondary nervation, arising from the mid-rib, is frequently dichotomised, and fairly close and oblique. In one or two places there appear to be anastomoses between the secondary nerves, but these are rare, and very possibly may be accounted for as accidents in the preservation.

This frond is quite unknown to me, but Mr. KIDSTON, to whom I have submitted the specimen, has suggested that it may perhaps be compared with DAWSON'S* genus *Megalopteris*, which is chiefly known from the Lower Coal Measures of Canada and the United States.† Unfortunately the specimen here figured will only permit me to assign it to this genus in a most guarded manner, as it is too fragmentary to indicate the real habit of the frond. So far as one can judge from the characters of the mid-rib and lateral nervation it agrees fairly well with *Megalopteris*. This genus has not so far been recorded from Britain. In some respects this plant also recalls the frond of *Glossopteris*, but it appears to me that the nervation is only very occasionally anastomosed, and that the union between the lateral veins is more apparent than real.

LYCOPODIALES.

Lepidodendron, STERNBERG, 1820. ('Flora der Vorwelt,' Heft 1, p. 23.)

1. *Lepidodendron aculeatum*, STERNBERG. Plate 19, fig. 8.

1820. *Lepidodendron aculeatum*, STERNBERG, 'Flora der Vorwelt,' Heft 1, pp. 20 and 23, Plate 6, fig. 2; Plate 8, fig. 1B, *a* and *b*.

1886. *Lepidodendron aculeatum*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 435, Plate 65, figs. 1-7.

The photograph reproduced on Plate 19, fig. 8, is taken from the only specimen of *Lepidodendron aculeatum* which has been obtained from the Culm Measures. It was found among the *débris* of the old culm workings at Summer Hiscott by Mr. ROGERS. The leaf bases are well preserved, and the prints of the ligule, the leaf scars, and the ridges on the keel are clearly seen.

* DAWSON (73), p. 51, Plate 17, figs. 191-4.

† ANDREWS (75), p. 415, Plate 46, figs. 1 and 1a.

2. *Lepidodendron obovatum* STERNBERG.

1820. *Lepidodendron obovatum*, STERNBERG, 'Flora der Vorwelt,' Heft 1, pp. 20 and 23, Plate 6, fig. 1 ; Plate 8, fig. 1A, *a* and *b*.

1886. *Lepidodendron obovatum*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 442, Plate 66, figs. 1-8.

The only specimen of this species which I have seen from the Culm Measures is in the HALL collection of the Athenæum Museum, Barnstaple. It was obtained from Greenacliff, on the coast some 3 miles to the west of Bideford.

3. *Lepidodendron fusiforme* (CORDA). Plate 19, fig. 5.

1903. *Lepidodendron fusiforme*, KIDSTON, 'Trans. Roy. Soc.,' Edinb., vol. 40, Part 4, p. 809, Plate 2, figs. 17 and 18 ; Plate 3, figs. 22-25.

The specimen of *Lepidodendron fusiforme* figured on Plate 19, fig. 5 was obtained from Broadstone quarry, Bideford, and is the only example known from the Culm Measures. This species, which has become involved in considerable confusion, has recently been defined and re-described by Mr. KIDSTON (see above), who has also published further figures of British specimens. It occurs in all the divisions of the British Coal Measures.

Lepidophloios, STERNBERG, 1825. ('Flora der Vorwelt,' Heft 4, p. xiii.)

Lepidophloios acerosus (L. and H.). Plate 19, fig. 9.

1831. *Lepidodendron acerosum*, LINDLEY and HUTTON, 'Fossil Flora,' vol. 1, Plate 7, fig. 1 ; Plate 8.

1893. *Lepidophloios acerosus*, KIDSTON, 'Trans. Roy. Soc.,' Edinb., vol. 37, Part 3, p. 558, Plate 1, figs. 1, 1*a* ; Plate 2, fig. 9.

The photograph on Plate 19, fig. 9 represents a small fragment of *Lepidophloios acerosus* from the carbonaceous shales at Summer Hiscott. It is the only specimen of the genus which has been obtained from the Culm Measures.

Sigillaria, BRONGNIART, 1822. ('Sur Class. végét. foss.,' p. 9.)

1. *Sigillaria tessellata*, BRONGNIART. Plate 19, fig. 7.

1828. *Sigillaria tessellata*, BRONGNIART, 'Hist. végét. foss.,' p. 436, Plate 156, fig. 1 ; Plate 162, figs. 1-4.

1886. *Sigillaria tessellata*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 561, Plate 85, figs. 1-9 ; Plate 86, figs. 1-6.

The photograph, reproduced on Plate 19, fig. 7, is taken from a fine specimen of *Sigillaria tessellata* obtained from the old culm workings at Summer Hiscott. This is the only example of this species which has, as yet, been found in the Culm Measures.

2. *Sigillaria scutellata*, BRONGNIART. Plate 19, fig. 4.

1828. *Sigillaria scutellata*, BRONGNIART, 'Hist. végét. foss.,' p. 455, Plate 150, figs. 2 and 3; Plate 163, fig. 3.

1886. *Sigillaria scutellata*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 533, Plate 82, figs. 1-6 and 9.

The large stem of *Sigillaria scutellata*, of which a portion is figured on Plate 19, fig. 4, was obtained by Mr. ROGERS from the sandstones at Pit quarry, Abbotsham, and is remarkably well preserved for a sandstone cast. The form of the leaf scar is clearly seen. The same species has also been obtained from the carbonaceous shales at Broadstone quarry, Bideford. Decorticated *Sigillarias* of the *Rhytidolepis* type are very abundant in several localities, but are too badly preserved to permit of specific determination.

Stigmaria, BRONGNIART, 1822. ('Sur. Class. végét. foss.,' p. 9.)

Stigmaria ficoides (STERNBERG).

1886. *Stigmaria ficoides*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 611, Plate 91, figs. 1-6.

1887. *Stigmaria ficoides*, WILLIAMSON, 'Palæont. Soc.,' vol. 40, pp. 1-4, 1-62, Plates 1-15.

Several specimens of *Stigmaria* have been obtained from the shales at Broadstone quarry and Warmington Farm, near Bideford, and from the sandstones at Pit quarry, Abbotsham. There is also a specimen in the British Museum (V. 3561) from Northam.

CORDAITALES.

Cordaites, UNGER, 1850. ('Gen. et Spec. Plant. Foss.,' p. 277.)

Cordaites (Artisia) sp.

1837. *Sternbergia approximata*, LINDLEY and HUTTON, 'Foss. Flora,' vol. 3, Plates 224 and 225.

1886. *Artisia approximata*, ZEILLER, 'Flore foss. bass. houill. Valenciennes,' p. 634, Plate 94, figs. 2 and 3.

The only Cordaitean remains which have been obtained from the Culm Measures were badly preserved pith casts, known as *Artisia* or *Sternbergia*, collected

from the sandstones at Broadstone quarry, Bideford, and from a small quarry above Westward Ho !.

Incertæ sedis.

Trigonocarpus, BRONGNIART, 1828. ('Prodr. Hist. végét. foss.,' p. 137.)

Trigonocarpus parkinsoni, BRONGNIART.

1835. *Trigonocarpum Næggerathi*, LINDLEY and HUTTON, 'Foss. Flora,' vol. 2, Plate 142c.

1836. *Trigonocarpum olivæforme*, LINDLEY and HUTTON, *ibid.*, vol. 3, Plate 222, figs. 1 and 3.

The only specimen of this seed known from the Culm Measures was obtained from the sandstones of Pit quarry, Abbotsham, and is in Mr. ROGERS's collection.

Bark-like Impression of a Fossil Plant. Plate 20, fig. 12.

The magnified photograph reproduced on Plate 20, fig. 12, is taken from one of several specimens of the bark-like impression of a fossil plant, obtained by Mr. ROGERS from the carbonaceous shales at Hiscott, and at Broadstone quarry, Bideford. The bark is ornamented by fairly regular "cross hatching," or striae, more or less at right angles to one another. The occurrence of leaf or of branch scars has never been observed on any specimens. The scar-like prominences seen in the photograph are entirely due to imperfections in the preservation. Mr. KIDSTON has obtained similar specimens from other British coal-fields. At present, however, we are quite without evidence as to the genus or class of plant to which these bark-like structures belong. They may possibly be impressions of the sub-epidermal tissues of partially decorticated stems, which would account for the absence of leaf scars.

B. THE PALÆOBOTANICAL EVIDENCE WITH REGARD TO THE AGE OF THE
CULM MEASURES IN NORTH-WEST DEVON.

V. *Previous Opinion.*

The first definite evidence as to the age of the "anthracite or culm" beds in North-west Devon was brought forward by DE LA BECHE in 1834. As has been already stated, the plants collected by DE LA BECHE from the coal-bearing beds near Bideford were determined by LINDLEY, and in a letter communicated to the Geological Society at the end of that year, it was stated that the specimens were "plants of the coal measures." *

In 1836, SEDGWICK and MURCHISON,† in a preliminary note on the classification of

* DE LA BECHE (34), p. 106.

† SEDGWICK and MURCHISON (36), pp. 95 and 96.

the rocks of North Devon, showed that the Culm Measures, "which had been previously regarded as belonging to one of the lowest portions of the grauwacke formation," may "without hesitation be referred to the regular carboniferous series." The abstract of their paper* before the Geological Society, published in 1837, contains a list of Carboniferous plants from the Bideford district as has already been noticed.

In the magnificent treatise on the "Physical Structure of Devonshire" by the same authors, which was read before the Geological Society in June, 1837, and published three years later in the 'Transactions,' the Carboniferous age of the Culm Measures was fully demonstrated. Although expressing some uncertainty as to the particular horizon in the Carboniferous to which their lower division of the Culm Measures belonged, they had no hesitation in placing the upper series, in which the bands of "anthracite or culm" occur, in the Upper Carboniferous. "But, we repeat, no such ambiguity attaches to the upper part of the culm series; as all the vegetable fossils derived from it, are identical with published species, before obtained, from the true coal measures overlying the mill-stone grit." "The upper culm strata of Devon are the geological equivalents of the ordinary British coalfields."†

The correctness of the identification of the plants from the Upper Culm Measures was further emphasised by MURCHISON in his 'Silurian System,' published in 1839. He‡ states that "several of the plants common to the Salopian and Pembroke coalfields are the *most abundant* species in the *culm measures of Devon*." On this point, Professor LINDLEY, after a re-examination of many specimens, expressed the following opinion: "Respecting the Devon culm plants, I have still the same observation to make as before. I have looked them over carefully, and *I do not see one single species* which might not have been met with at Newcastle, with the exception of two round compressed bean-like bodies, which, if of vegetable origin, are unknown to me."§

DE LA BECHE|| in his 'Report on the Geology of Cornwall and Devon,' also published in 1839, discussed the evidence as to the age of the Upper Culm Measures, and gave reasons for his belief that fossil plants afford little or no clue to the stratigraphical horizon of the beds in which they occur. His position in this matter was, however, explained by LYELL¶ in his Presidential address to the Geological Society in 1837. SEDGWICK and MURCHISON's conclusions were fully accepted by LYELL, and also by AUSTEN,** WEAVER†† and others, although there were still a few,

* *Ibid.* (37), p. 562.

† SEDGWICK and MURCHISON (40), pp. 684 and 682.

‡ MURCHISON (39), p. 380, footnote; see also p. 85 and p. 374, footnote.

§ MURCHISON (39), p. 380, footnote.

|| DE LA BECHE (39), pp. 131-139.

¶ LYELL (37), pp. 490-496.

** AUSTEN (42), pp. 458-461.

†† WEAVER (38), p. 589.

especially WILLIAMS,* who strongly upheld the earlier view of the pre-Carboniferous age of these deposits.

For more than a quarter of a century after the publication of SEDGWICK and MURCHISON's treatise, no attention seems to have been devoted to the Upper Culm Measures in North Devon. In 1866, however, a local geologist, the late Mr. TOWNSHEND HALL,† who possessed an intimate acquaintance with the Culm Measures of the Bideford district, stated that he regarded these beds as the equivalents of the Millstone Grit in other areas. In subsequent papers‡ he maintained this view, namely, that their age was immediately antecedent to that of the true Coal Measures.

PENGELLY, in his Presidential address to the Devonshire Association in 1867, stated that the Carboniferous beds of Devonshire “are admitted on all hands to be the equivalents of the Coal-measures.”§ A similar conclusion was expressed by HOLL|| with regard to the South Devon Culm Measures.

In 1872, the fifth edition of MURCHISON's ‘Siluria’ was published, and the various petrological types of the Culm Measures are here referred to definite horizons in the Carboniferous. The limestones of Swimbridge and Venn represent a part of the Mountain or Carboniferous Limestone. The Coddon Hill beds¶ stand in place of the Millstone Grit, and the overlying Culm are the equivalents of some of the lower coal-bearing strata in other areas.**

In the fourth edition of ‘The Coal-fields of Great Britain,’ Professor HULL speaks of “the flora of the ‘Culm’ belonging to the Lower Carboniferous series of Devonshire.”††

Mr. H. B. WOODWARD‡‡ in the second edition of ‘The Geology of England and Wales’ published in 1887, speaking of the Devonshire Culm Measures says “some authorities have placed them, generally, on the horizon of the Millstone Grit, but there seems to be good reason to include with them representatives of at least a portion of the true Coal-measures, and also of the Carboniferous Limestone and Lower Limestone Shales. The following general divisions may be made in the Series :—

* WILLIAMS (35), (37), (39), (40), (42).

† HALL (66).

‡ HALL (75), p. 368, and (78).

§ PENGELLY (67), p. 15.

|| HOLL (68), p. 414.

¶ These beds were shown to be of Lower Carboniferous age by Messrs. HINDE and FOX in 1895.

** MURCHISON (72), pp. 272 and 273.

†† HULL (81), p. 64.

‡‡ WOODWARD (87), p. 197.

Culm-measure Series	{	Lower Coal-measures? ...	{	Thick even-bedded grey grits with slates and shales. Sandstones, grits and shales, with beds of culm.
		Millstone Grit? ...		Coddon Hill Beds (local).
		Lower Carboniferous? ...		Shales, with thin grits, imper-sistent limestones and occasional bands of culm."

In more recent times, however, there would seem to be a tendency in certain quarters to regard the Culm Measures as essentially a Lower Carboniferous series of deposits. The opinion of Professor HULL, already quoted, is a case in point. This view is not, however, shared by all British Geologists. It has arisen, partly from the fact that the older literature has to some extent been lost sight of, and partly from the interest aroused by the recent work of Messrs. HINDE and FOX, which placed our knowledge of the Lower Carboniferous portion of the Culm Measures on an altogether different footing to any which we possess of the Upper Culm Measures. We have also in recent years gained a more intimate acquaintance with the flora of the so-called culm, or kulkm of Germany, Austria, and elsewhere on the Continent; deposits of Lower Carboniferous age as shown by the character of their fossil remains. The identification by Mr. KIDSTON* of certain Lower Carboniferous species of plants believed to have been obtained from the Culm Measures, but which, as already shown, were mostly derived from the Upper Devonian, has been quoted by WOODWARD,† USSHER‡ and others in this connection.

It is one of the main objects of the present paper to show that the view that the Culm Measures as a whole are essentially of Lower Carboniferous age is incorrect.

Lastly, the opinion of Mr. USSHER, who has by far the widest acquaintance with the Culm Measures of any living geologist, and who has devoted many years to their exploration on behalf of the Geological Survey, may be quoted as having considerable weight. In his earlier papers,§ Mr. USSHER does not offer any opinion as to the horizons in the Upper Carboniferous represented in Devon, and in 1888, he|| remarks "that he doubts the value of any correlation of these divisions with those of the Carboniferous of other parts of England, but gives the following for what it is worth."

* KIDSTON (84¹) and (84²).

† WOODWARD (87), p. 197.

‡ USSHER (92), p. 160.

§ USSHER (79), (86), (87).

|| USSHER (88), p. 141.

Upper Culm Measures	= ? Lower Coal measures or Millstone Grit.
Middle Culm Measures	} Millstone Grit.
Lower Culm Measures { St. David's type Coddon Hill beds and impersistent limestones.	
	} Carboniferous Limestone.

In his more recent papers,* published in 1892 and 1901, Mr. USSHER apparently inclines to the opinion that the higher divisions of the Culm Measures are the equivalents of the Millstone Grit, although he does not express any very decided views.

VI.—*The Middle Coal Measures of the Bideford District.*

We have seen from the summary of previous opinion with regard to the Upper Culm Measures, that the age of these beds was first determined as Upper Carboniferous, by DE LA BECHE, and by SEDGWICK and MURCHISON, entirely on the evidence of the fossil flora; a striking illustration of the contributions of Palæobotany to Stratigraphical Geology.

In recent years, we have come to know more of the distribution of fossil plants in the Coal Measures of this country, chiefly as the result of Mr. KIDSTON's researches,† and it is now possible to distinguish clearly a certain number of horizons in the Upper Carboniferous, by the character of the flora. The tests applied are, as I have recently explained elsewhere,‡ entirely different from those made use of in zoning the Lower Palæozoic and Jurassic rocks by means of the invertebrate remains. At the beginning of Upper Carboniferous times, a marked change in the character, but not in the general relationships of the flora, took place. So marked was this break that, although, so far as we are aware, most of the genera of both Upper and Lower Carboniferous rocks belong to the same families and classes, yet no species of reliable value is known to occur in both these great divisions.

During Upper Carboniferous and Permian times, periods which belong to the same botanical epoch, and are somewhat sharply marked off botanically from the Lower Carboniferous and Upper Devonian, the general character of the flora in its broad outlines remained constant. Yet detailed study has shown that it is possible to detect the changes which took place during this interval, involving the gradual coming in or dying out of genera and species, and the maximum development of now one genus and now another. That a considerable change did take place is evident from a comparison of the two extremes of these series, the Permian flora of the Continent, now known in great detail, and the flora of the British Lower Coal Measures.

* USSHER (92), p. 179, and (01), p. 386.

† KIDSTON (93).

‡ ARBER (03).

The whole principle of zoning the Carboniferous system by means of fossil plants, whether in this country or abroad, depends upon the recognition of definite periods in this change, periods in which the change itself has become rather marked. Many species extend throughout the Upper Carboniferous, but this is by no means the case with all. Some genera, and many species have a far shorter vertical distribution than others, and their presence gives a dominant character to the flora at any one horizon. By themselves, these species are unreliable as evidence, if only from the danger of negative evidence, but by taking into account the aggregate flora at any one horizon the evidence gained is found to be trustworthy.

Briefly, we can so far distinguish four palæobotanical sub-divisions of the Upper Carboniferous.

Examples.

- (4) Upper Coal Measures . . . { Radstock and Farrington Series, Somerset.*
Upper Pennant Series, South Wales.†
- (3) Upper Transition Series . . . { Lower Pennant Series, South Wales.†
Ardwick Series, Manchester.
- (2) Middle Coal Measures . . . Dudley Coalfield, South Staffordshire.
- (1) Lower Coal Measures . . . Gannister beds of Lancashire and Yorkshire.

Returning to the Upper Culm Measures of the Bideford district, the following species have been found to occur, and their distribution in the Upper Carboniferous of Britain is as follows :—

Distribution of Upper Carboniferous Species which occur in the Upper Culm
Measures of the Bideford District.

× = recorded, × × = especially abundant on this horizon, (×) = rare on this horizon.

Species.	Lower Coal Measures.	Middle Coal Measures.	Upper Transition Series.	Upper Coal Measures.
Equisetales—				
<i>Calamites (Calamitina) undulatus</i> , STERNB. .	× ×	× ×		(×)
<i>C. (Eucalamites) ramosus</i> , ARTIS	× ×	× ×	×	×
<i>C. (Stylocalamites) suckowi</i> , BRONG. . . .	× ×	× ×		×
<i>C. (Calamitina) varians</i> , STERNB.	×	×		
<i>Annularia radiata</i> , BRONG.	× ×	× ×		
<i>A. galioides</i> (L. and H.)	×	×		
<i>Calamocladus equisetiformis</i> (SCHL.) . . .	× ×	× ×	×	× ×
<i>C. characiformis</i> (STERNB.)		×	×	
<i>Calamostachys longifolia</i> , WEISS.	×	×		
Sphenophyllales—				
<i>Sphenophyllum cuneifolium</i> (STERNB.) . .	× ×	× ×	×	

* Kidston (88).

† Kidston (94).

Distribution of Species—*continued*.

Species.	Lower Coal Measures.	Middle Coal Measures.	Upper Transition Series.	Upper Coal Measures.
Cycadofilices—				
<i>Neuropteris obliqua</i> (BRONG.)	×	×		
<i>N. schlehani</i> , STUR.		×		
<i>Alethopteris serli</i> (BRONG.)		(×)	(×)	× ×
<i>A. lonchitica</i> (SCHL.)	× ×	× ×	(×)	(×)
Filicales ?—				
<i>Mariopteris muricata</i> (SCHL.)	× ×	× ×		(×)
<i>Urnapteris tenella</i> (BRONG.)	×	×		
<i>Renaultia footneri</i> (MARRAT)	×	×		
Lycopodiales—				
<i>Lepidodendron aculeatum</i> , STERNB.	× ×	× ×		× ×
<i>L. obovatum</i> , STERNB.	× ×	× ×		
<i>L. fusiforme</i> (CORDA).	×	×		×
<i>Lepidophloios acerosus</i> (L. and H.)	×	×	×	
<i>Sigillaria scutellata</i> , BRONG.	×	×	×	
<i>S. tessellata</i> , BRONG.	(×)	× ×	×	
<i>Stigmaria ficoides</i> (STERNB.).	× ×	× ×	× ×	× ×
<i>Incertæ Sedis—</i>				
<i>Trigonocarpus parkinsoni</i> , BRONG.	×	×	×	

*Additional Generic, and doubtful Specific Determinations.**Equisetales.—**Calamites* sp. (external surface).*Pinnularia* sp.*Filicales ?—**Megalopteris* sp ?*Renaultia schatzlarensis* (STUR.) ?*Cordaitales.—**Cordaites* (*Artisia*) sp.*Incertæ Sedis.—*

Bark-like impression.

The general character of this flora is identical with that developed elsewhere in Britain in the Middle Coal Measures. As will be seen from the above table, the majority of the species determined are known to occur in both the Lower and Middle Coal Measures. But there are also present several which have, so far, never been found on the lower horizon. The flora of the Middle Coal Measures is everywhere distinguished by the occurrence of such species. In other words, the change in the

general character of the flora of the Upper Carboniferous, as traced from the base to the summit, is already marked on this horizon by the presence of new species which are not found in the lowest beds. *Neuropteris schlehani*, *Alethopteris serli*, and *Calamocladus charæformis* are unknown from the Lower Coal Measures, while *Sigillaria tessellata* and *Neuropteris obliqua* are markedly more abundant in the Middle than the Lower Coal Measures. The common occurrence of *Sigillaria*, a genus which reaches its maximum in the Middle Coal Measures, and which is neither frequent nor represented by many species on the lower horizon, adds confirmatory support to this conclusion.

This flora is further distinguished from that of the Upper Transition Series and the Upper Coal Measures by the entire absence of certain genera or species, especially *Pecopteris* and its allies, which are characteristic of those horizons, as well as by the fact that many of the species described here are either entirely unknown from, or of very rare occurrence in the higher beds.

The main conclusion of this paper is, therefore, that the coal-bearing horizon in the Upper Culm Measures, developed in the Bideford district, is equivalent to the Middle Coal Measures in other British coalfields.

VII. *General Conclusions.*

It has been already pointed out that the thickness and extent of the Upper Culm Measures of SEDGWICK and MURCHISON (a division which practically includes the Middle and Upper Culm Measures of Mr. USSHER's* classification), is far greater than that of the Lower Culm Measures.†

Thus there can be no doubt that the Culm Measures of Devon, as a whole, are essentially of Upper Carboniferous age, although Lower Carboniferous beds are also represented. The age of the latter series was determined by Messrs. HINDE and FOX in 1895, as the result of an examination of a large and varied fauna, more especially derived from the Coddon Hill series. As might be expected from the marine character of these beds, few fossil plants have ever been obtained from them.‡

Above the chert deposits lie the great series of the shales and sandstones which constitute the Upper Culm Measures. If we follow the valley of the Torridge from its junction with the Taw, as far south as Torrington, we pass directly across the line of strike of the Upper Culm Measures, from the lowest to the highest, or approximately the highest beds.

At Instow Quay, a half-mile to the south of the junction of the two rivers, we find

* USSHER (01), p. 362.

† See SEDGWICK and MURCHISON (40), p. 677; HINDE and FOX (95), p. 662; and Mr. USSHER's map (01), Plate 16.

‡ A few doubtful species have been recorded from the limestones (see USSHER (92), pp. 124, 127, 128, and 130).

the first link in the chain of evidence. The beds here consist of shales alternating with sandstones, the former containing many distinctly calcareous nodules. It was from these shales and nodules that the late TOWNSEND HALL,* in 1876, recorded the fish and Goniatite remains, which are now preserved in the British Museum (Natural History). The fish remains are esturine, and belong to the following species :—

Coelacanthus elegans, NEWB.†

Elonichthys aitkeni, TRAQ.‡

Both of these are known only from the Upper Carboniferous, and occur in the Lower Coal Measures, although they are not confined to that horizon.§

In addition, the following Cephalopoda have been found in the calcareous shales :—

Gastrioceras carbonarium (VON BUCH).||

Gastrioceras Listeri (MARTIN).¶

Both these species are, I believe, abundant in the Lower Coal Measures in this country. It may be mentioned that since HALL's specimens are much water-worn, and might conceivably give rise to the suspicion that these shales were not found in place, I have had the Instow beds carefully re-examined, with the result that further specimens of the Goniatites, and also specimens of *Pterinopecten* (*Aviculopecten*) *papyraceus*, (Sow.) have been obtained, which were undoubtedly *in situ*. The only plant remains which have been found at Instow are imperfect Calamitean casts.

These discoveries afford strong evidence that the Culm Measures at Instow belong to the lowest portion of the Upper Carboniferous,** an horizon known to the palæobotanist as the Lower Coal Measures.††

Passing some $2\frac{1}{2}$ miles to the south of Instow, we reach, at Bideford, a higher horizon in the Culm Measures, which has been shown here to be the equivalent of the Middle Coal Measures in other British areas. These beds are of a

* HALL (76), p. 410; see also HINDE and FOX (95), p. 655.

† Registered numbers in Geological Department, P. 5379 and P. 6268.

‡ P. 6100.

§ TRAQUAIR (03), p. 700.

|| C. 1613.

¶ C. 1613A.

** Messrs. HINDE and FOX (95), p. 663, however, have expressed a doubt as to whether these beds should be included in the Upper Culm Measures.

†† The Millstone Grit is no longer regarded as a separate horizon, either by the palæobotanists, or the palæozoologists who are working at the distribution of carboniferous life, for both its flora and fauna are indistinguishable from that of the Lower Coal Measures.

shallow water or estuarine facies, as is shown by the abundance of plant remains. In addition to the plants described here, the following mollusca, kindly determined for me by Dr. WHEELTON HIND, were obtained at Bideford in association with plant remains :—

Carbonicola acuta (Sow.).

C. aquilina (Sow.) ?

So far we have seen that there are good reasons for the belief that both the Lower and Middle Coal Measures are represented in Devon. With regard to the higher beds developed near Torrington, and along the northern and western coast lines in the neighbourhood of Clovelly and Hartland, there is no evidence at present as to the position which they occupy in the Upper Carboniferous series. So far, I have hardly obtained any plants from these beds, but it is hoped that a more thorough and extended examination, which is shortly to be undertaken, will yield evidence as to the horizon to which they belong. This portion of the Culm Measures has never been studied in detail, and remains practically virgin ground for the geologist.* The highest beds are termed by Mr. USSHER† the Eggesford Grits or Upper Culm Measures, in his three-fold classification. I have had some opportunity of examining these rocks, but I have found it almost impossible to distinguish them clearly by their lithological or physical characters from the shales and sandstones of the Morehard type (Middle Culm Measures of Mr. USSHER), from which the plants described here were obtained. For this reason the original two-fold division of the Culm Measures into Upper and Lower, instituted by SEDGWICK and MURCHISON, has been maintained here.

It would be out of place in a paper, which is botanical rather than geological, to attempt to institute a detailed comparison between the lithological characters of the Carboniferous sequence in Devon, and those of other Carboniferous areas in Britain or on the Continent. There are, however, two points which may be briefly discussed. While the Lower Carboniferous portion of the Culm Measures, with its comparatively feeble development of calcareous deposits, and its considerable thickness of Radiolarian cherts, differs as a whole somewhat markedly from the Lower Carboniferous rocks of many other British areas,‡ this is not the case in the same degree with the Upper Carboniferous division. The sandstones and shales of the Upper Culm Measures recall somewhat vividly those of certain other English coalfields. The presence of numerous plant remains in this division of the Culm Measures points to conditions of

* So far as I am aware, the only literature, with the exception of Mr. USSHER's papers, is a short note by CONYBEARE (14), published in 1814, on the Culm Measures near Clovelly.

† USSHER (01), pp. 362 and 366.

‡ It has been long known that rocks of similar petrological character to the Lower Culm Measures of Devon occur in the upper portion of the Lower Carboniferous sequence ("Gower Series" or "Bishopston Beds") in South Wales. See DE LA BECHE (46), p. 133, &c., and WOODWARD (87), pp. 167 and 172.

deposition not wholly dissimilar to those which pertained in other areas. The occasional occurrence of marine calcareous bands,* which has now been demonstrated on more than one horizon in Devonshire, is a feature common to other British coalfields, more especially those in North Staffordshire, and South Lancashire. The general absence of carbonaceous deposits in Devon remains the most remarkable feature of these beds, and in this respect the Culm Measures of Devon are sharply contrasted with other Carboniferous areas in England.

It is peculiarly unfortunate, as Professor LEBOUR† pointed out some years ago, that the term Culm or Kulm has become generally applied to certain series of deposits more especially developed in Germany and Austria.

SEDGWICK and MURCHISON were the first, as we have seen, to adopt the Devonshire name for the impure coal occurring near Bideford, and to institute the term Culm Measures. These authors,‡ at the conclusion of their researches in Devon, examined the Carboniferous rocks of Westphalia and other areas in Germany, and instituted a close comparison with the Culm Measures. Since then, the term Culm seems to have been adopted by most Continental geologists. Yet these deposits, however much they may physically resemble the Devonshire rocks, are of different ages. The comparison instituted by SEDGWICK and MURCHISON between the British and German rocks, and supported in more recent times by Mr. USSHER,§ and MESSRS. HINDE and FOX,|| is no doubt true of that portion of the Devonshire Culm Measures which is of Lower Carboniferous age, but this, as has been already pointed out, is now known to represent a comparatively small fraction of the Carboniferous series of Devon and the adjacent counties; a series which, as a whole, is essentially Upper, and not Lower Carboniferous in age. On the other hand, the sequence of so-called Culm or Kulm deposits in Silesia, Moravia, the Hartz, Westphalia and elsewhere in Germany, has yielded a series of plant remains which are now well known from the researches of STUR, GÖPPERT, POTONIÉ and others, and which are typically and entirely of a Lower Carboniferous facies.

Professor LEBOUR¶ has suggested that the Germanised form of the word Culm, *i.e.*, Kulm, should be adopted for the Continental deposits exclusively, in order to minimise the confusion which must constantly arise with regard to these two non-contemporaneous series. It would seem to me better, if possible, to drop the term Culm Measures altogether in speaking of the Devon Carboniferous rocks, and to apply the nomenclature adopted with regard to other British areas of similar age, which has been shown here to be applicable to Devonshire, at least with regard to the

* HALL (76), and ROGERS and ARBER (04).

† LEBOUR (79), p. 352.

‡ SEDGWICK and MURCHISON (42), p. 276.

§ USSHER (92), p. 169 ; (01), p. 374.

|| HINDE and FOX (95), p. 658.

¶ LEBOUR (79), p. 353.

Upper Carboniferous deposits. As, however, this suggestion may not be altogether practicable, I have retained the term "Culm Measures" in this paper in order to avoid confusion.

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EXPLANATION OF THE PLATES.

(Photographs by Mr. TAMS, Cambridge.)

PLATE 19.

Fig. 1. *Calamites (Calamitina) undulatus*, STERNB.

A portion of a pith cast showing a node, and two internodes. The sinuous character of the longitudinal ridges is well seen, also the infranodal canals, and the wedge-like endings of the ridges at the node. Very slightly enlarged. (Mr. ROGERS'S Coll. No. 18, from the cliff above Bideford railway station.)

Fig. 2. *Calamites (Eucalamites) ramosus*, ARTIS.

A portion of a pith cast showing part of an internode, and a large branch scar at the node. Natural size. (Mr. ROGERS'S Coll. No. 12, from the cliff above Bideford railway station.)

Fig. 3. *Calamites (Calamitina) undulatus*, STERNB.

A pith cast showing two nodes. The longitudinal ridges on the internodes are sinuous. The terminations of the ridges and the infranodal canals below the nodes are clearly seen. Reduced to half natural size. (Mr. ROGERS'S Coll. No. 11, from the cliff above Bideford railway station.)

Fig. 4. *Sigillaria scutellata*, BRONG.

Natural size. (Mr. ROGERS'S Coll. No. 10, from the sandstones of Pit (ROGERMAN'S) quarry, Abbotsham, near Bideford.)

Fig. 5. *Lepidodendron fusiforme* (CORDA).

$\times 2\frac{1}{2}$. (Mr. ROGERS'S Coll. No. 54, from Broadstone quarry, East-the-Water Bideford.)

Fig. 6. *Urnatopteris tenella* (BRONG.).

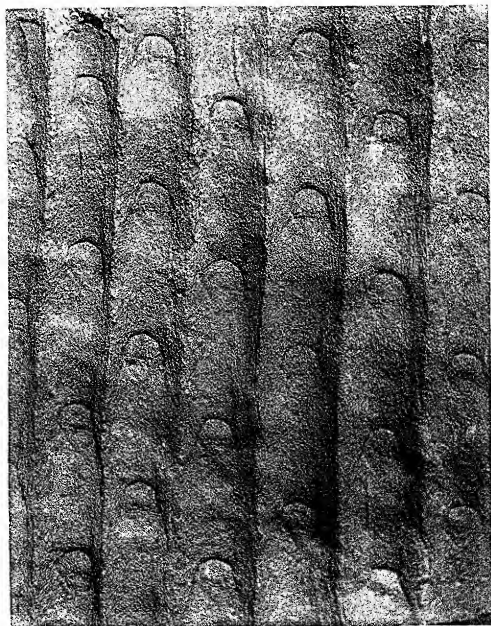
Photograph from a drawing, $\times 2\frac{1}{2}$. (Mr. ROGERS'S Coll. No. 20, from ROBERTS'S quarry, East-the-Water, Bideford.)

Fig. 7. *Sigillaria tessellata*, BRONG.

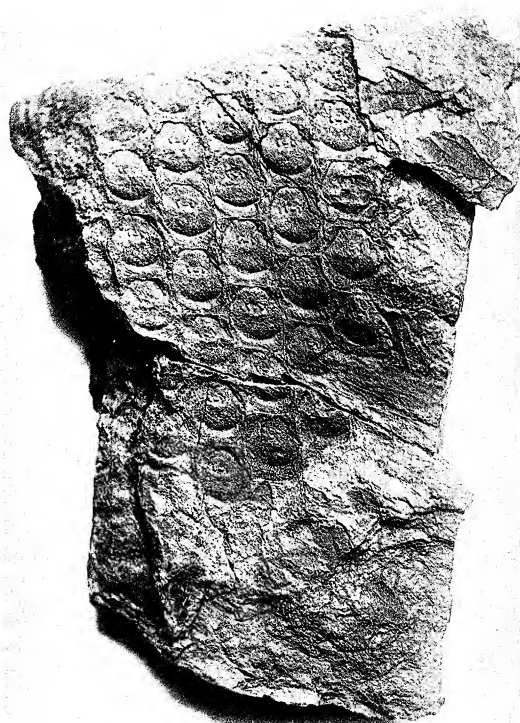
Natural size. (Mr. ROGERS'S Coll. No. 39, from the Culm bands at Hiscott, near Tawstock.)



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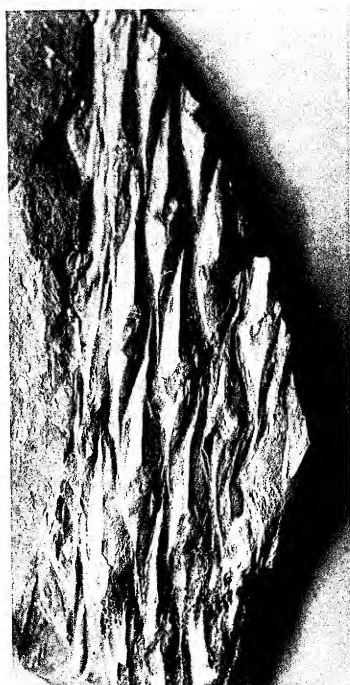
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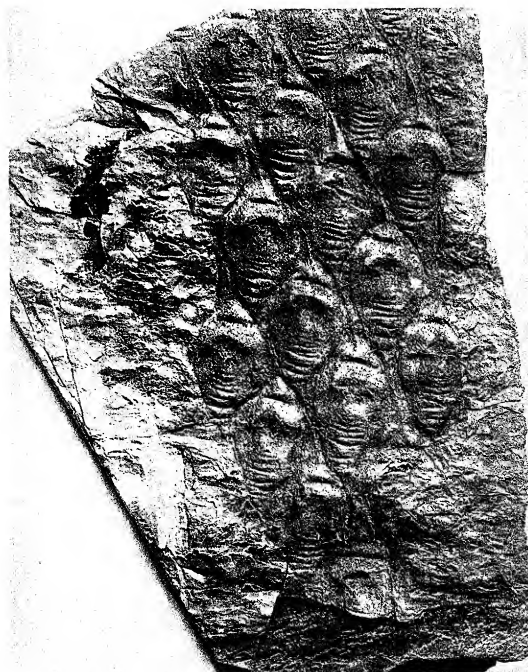
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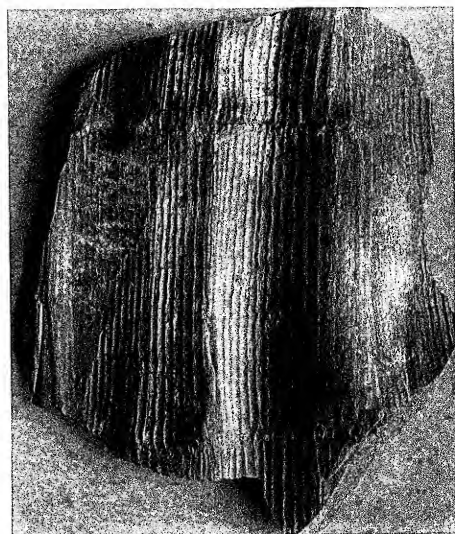
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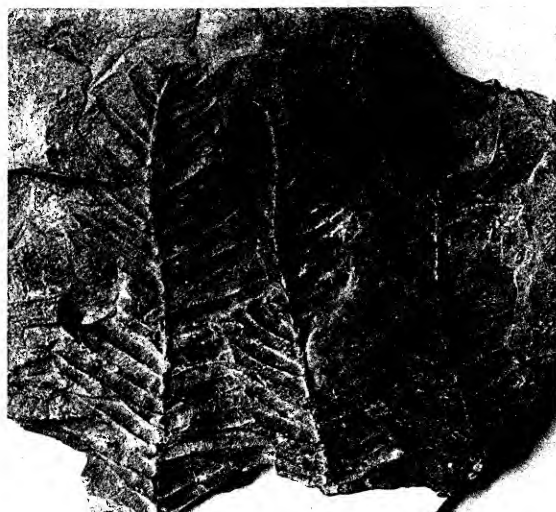
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Fig. 8. *Lepidodendron aculeatum*, STERNB.

Natural size. (Mr. ROGERS'S Coll. No. 21, from the Culm bands at Hiscott, near Tawstock.)

Fig. 9. *Lepidophloios acerosus* (L. and H.).

Slightly enlarged. (Mr. ROGERS'S Coll. No. 40, from the Culm bands at Hiscott, near Tawstock.)

PLATE 20.

Fig. 10. *Neuropteris schlehani*, STUR.

A fragment of a pinna, showing the form and nervation of the pinnules. $\times 3\frac{1}{4}$. (Mr. ROGERS'S Coll. No. 50, from Broadstone quarry, East-the-Water, Bideford.)

Fig. 11. *Alethopteris lonchitica* (SCHL.).

Natural size. (HALL Coll. in the Athenæum, Barnstaple, from Alverdiscott.)

Fig. 12. Unknown Bark of a plant. $\times 3\frac{1}{2}$. (Mr. ROGERS'S Coll., from Broadstone quarry, East-the-Water, Bideford.)

Fig. 13. *Neuropteris schlehani*, STUR.

A fragment of a pinna, showing the nervation. $\times 3\frac{1}{2}$. (Mr. ROGERS'S Coll. No. 51, from Broadstone quarry, East-the-Water, Bideford.)

Fig. 14. *Alethopteris serli* (BRONG.).

$\times 3\frac{1}{3}$. (Mr. ROGERS'S Coll. No. 42, from the Culm bands at Hiscott, near Tawstock.)

Fig. 15. *Alethopteris lonchitica* (SCHL.).

The terminal portion of a pinna of a form or variety of this species in which the pinnules are contracted at the base, and not decurrent. Natural size. (Museum of the Geol. Surv., Jermyn Street, No. 8423, from Moor Park, Bideford.)

Fig. 16. *Megalopteris* sp. ?

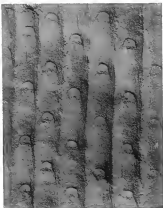
A portion of a pinnule showing the thick midrib, and dichotomous secondary nervation. Slightly enlarged. (HALL Coll., in the Athenæum, Barnstaple; from Alverdiscott.)

Fig. 17. *Mariopteris muricata* (SCHL.).

$\times 2\frac{1}{2}$. (SEDGWICK Mus. Camb., Carb. Plant Coll. No. 1148; from ROBERTS'S quarry, East-the-Water, Bideford.)



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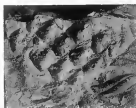
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PLATE 19.

Fig. 1. *Calamites (Calamitina) undulatus*, STERNB.

A portion of a pith cast showing a node, and two internodes. The sinuous character of the longitudinal ridges is well seen, also the infranodal canals, and the wedge-like endings of the ridges at the node. Very slightly enlarged. (Mr. ROGERS's Coll. No. 18, from the cliff above Bideford railway station.)

Fig. 2. *Calamites (Eucalamites) ramosus*, ARTIS.

A portion of a pith cast showing part of an internode, and a large branch scar at the node. Natural size. (Mr. ROGERS's Coll. No. 12, from the cliff above Bideford railway station.)

Fig. 3. *Calamites (Calamitina) undulatus*, STERNB.

A pith cast showing two nodes. The longitudinal ridges on the internodes are sinuous. The terminations of the ridges and the infranodal canals below the nodes are clearly seen. Reduced to half natural size. (Mr. ROGERS's Coll. No. 11, from the cliff above Bideford railway station.)

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Natural size. (Mr. ROGERS's Coll. No. 10, from the sandstones of Pit (ROGERMAN's) quarry, Abbotsham, near Bideford.)

Fig. 5. *Lepidodendron fusiforme* (CORDA).

$\times 2\frac{1}{2}$. (Mr. ROGERS's Coll. No. 54, from Broadstone quarry, East-the-Water Bideford.)

Fig. 6. *Urnatopteris tenella* (BRONG.).

Photograph from a drawing, $\times 2\frac{1}{2}$. (Mr. ROGERS's Coll. No. 20, from ROBERTS's quarry, East-the-Water, Bideford.)

Fig. 7. *Sigillaria tessellata*, BRONG.

Natural size. (Mr. ROGERS's Coll. No. 39, from the Culm bands at Hiscott, near Tawstock.)

Fig. 8. *Lepidodendron aculeatum*, STERNB.

Natural size. (Mr. ROGERS's Coll. No. 21, from the Culm bands at Hiscott, near Tawstock.)

Fig. 9. *Lepidophloios acerosus* (L. and H.).

Slightly enlarged. (Mr. ROGERS's Coll. No. 40, from the Culm bands at Hiscott, near Tawstock.)

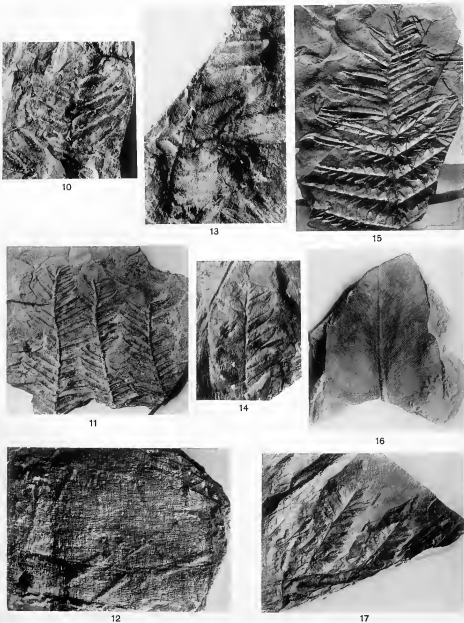


PLATE 20.

Fig. 10. *Neuropteris schlehani*, STUR.

A fragment of a pinna, showing the form and nervation of the pinnules. $\times 3\frac{1}{2}$. (Mr. ROGERS's Coll. No. 50, from Broadstone quarry, East-the-Water, Bideford.)

Fig. 11. *Alethopteris lonchitica* (SCHL.).

Natural size. (HALL Coll. in the Athenaeum, Barnstaple, from Alverdiscott.)

Fig. 12. Unknown Bark of a plant. $\times 3\frac{1}{2}$. (Mr. ROGERS's Coll., from Broadstone quarry, East-the-Water, Bideford.)

Fig. 13. *Neuropteris schlehani*, STUR.

A fragment of a pinna, showing the nervation. $\times 3\frac{1}{2}$. (Mr. ROGERS's Coll. No. 51, from Broadstone quarry, East-the-Water, Bideford.)

Fig. 14. *Alethopteris serli* (BRONG.).

$\times 3\frac{1}{2}$. (Mr. ROGERS's Coll. No. 42, from the Culm bands at Hiscott, near Tawstock.)

Fig. 15. *Alethopteris lonchitica* (SCHL.).

The terminal portion of a pinna of a form or variety of this species in which the pinnules are contracted at the base, and not decurrent. Natural size. (Museum of the Geol. Surv., Jermyn Street, No. 8423, from Moor Park, Bideford.)

Fig. 16. *Megalopteris* sp. ?

A portion of a pinnule showing the thick midrib, and dichotomous secondary nervation. Slightly enlarged. (HALL Coll., in the Athenaeum, Barnstaple; from Alverdiscott.)

Fig. 17. *Mariopteris muricata* (SCHL.).

$\times 2\frac{1}{2}$. (SEDGWICK Mus. Camb., Carb. Plant Coll. No. 1148; from ROBERTS's quarry, East-the-Water, Bideford.)